NASA Workshop

on

THE SUBORBITAL SCIENCE

SOUNDING ROCKET PROGRAM

12-13 November , 1991

Presentation Summary: Investigator Perspectives

Michael Mendillo
Professor of Astronomy

OUTLINE

1. SCIENCE PAYLOAD REQUIREMENTS

2. SUPPORTING SERVICES

3. "SPECIAL" REQUIREMENTS

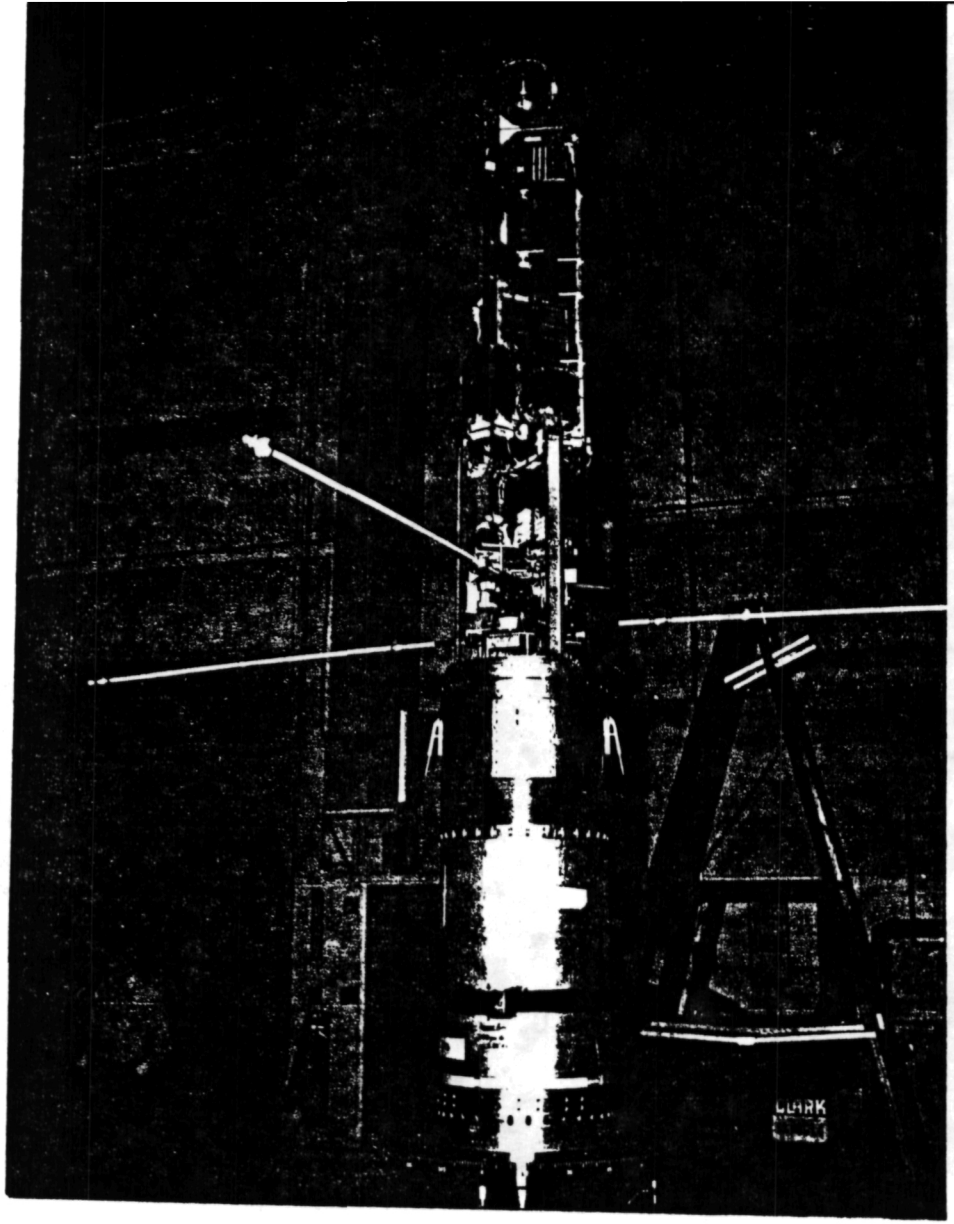
1. SCIENCE PAYLOAD REQUIREMENTS

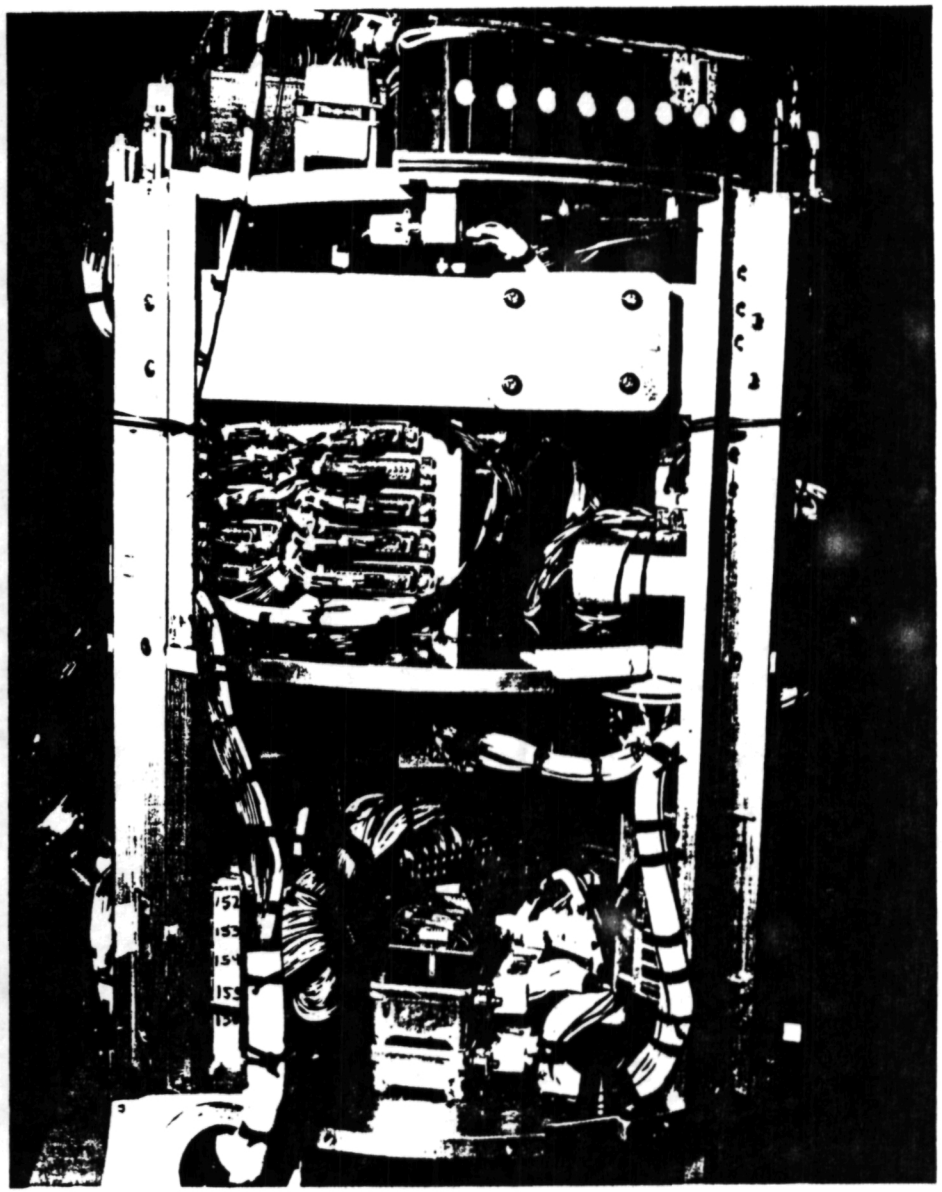
- Pointing --- "simple" (instrument $\perp \mathbf{B}_0$, $\parallel \mathbf{V}$, etc)
- Pointing --- "complex" (stellar, planetary, solar targets)
- Deployments -- Booms, shields, etc.
- Separations --- "Mother-Daughter" payloads, ejectables, etc.
- Chemical Releases --- Multiple species
- Payload Recovery Systems --- re-use, retrieve data
- Down Link Telemetry --- Date rates, decision points
- Up-link Commands

----- Above items currently a mix of PI/NASA provided.

EXAMPLES OF PAYLOADS

- Simple --- Chemical Releases to modify atmosphere
- Moderate --- In-situ probes of space environment
- Complex --- Short term platform for astronomical observations





CORNELL UNIVERSITY PAYLOADS

UNIVERSITY OF COLORADO
PLANETARY ROCKET PROGRAM

SCIENCE OBJECTIVES

- ULTRAVIOLET IMAGING AND SPECTROSCOPIC OBSERVATIONS OF MERCURY, VENUS, AND COMETS

SCIENCE INSTRUMENT

- A 40 CM DIAMETER CASSEGRAIN TELESCOPE AND A SPECTROGRAPH EQUIPPED WITH AN IMAGE INTENSIFIED TV CAMERA AND A CODACON MICROCHANNEL PLATE DETECTOR

- THE TELESCOPE SECONDARY MIRROR IS MOUNTED IN A TWO AXIS GIMBAL WHICH CAN BE MOVED DURING FLIGHT BY GROUND COMMANDS IN ORDER TO REPOSITION THE TARGET IMAGE ON THE ENTRANCE SLIT OF THE SPECTROGRAPH. POINTING ACCURACY AND STABILITY OF 1 ARC SECOND IS ACHIEVED USING THIS SYSTEM.

SPECIAL REQUIREMENTS

- A LARGE SUNSHADE MUST BE DEPLOYED AND RETRACTED DURING FLIGHT.

- THE ROCKET ATTITUDE CONTROL SYSTEM MUST POINT TO THE TARGET WITH HIGH PRECISION (WITHIN 3 ARC MINUTES) AND STABILITY (RESIDUAL MOTION LESS THAN 20 ARC SECONDS).

- THE EXPERIMENT USES A SENSITIVE , LIGHT-WEIGHT TELEVISION CAMERA TO MONITOR THE TARGET IMAGE AT THE FOCAL PLANE OF THE TELESCOPE.

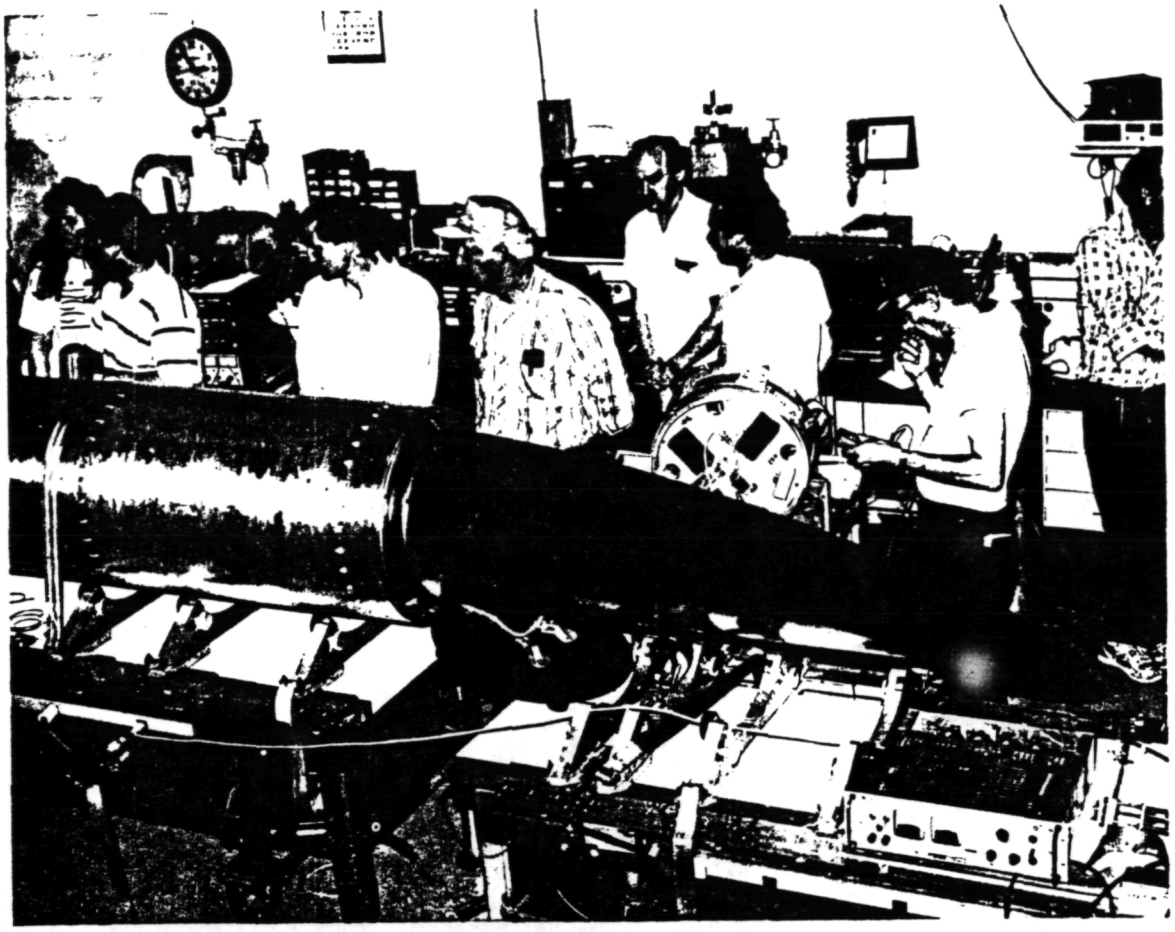
- INSTRUMENT FINE POINTING IS CONTROLLED BY GROUND COMMAND DURING FLIGHT.

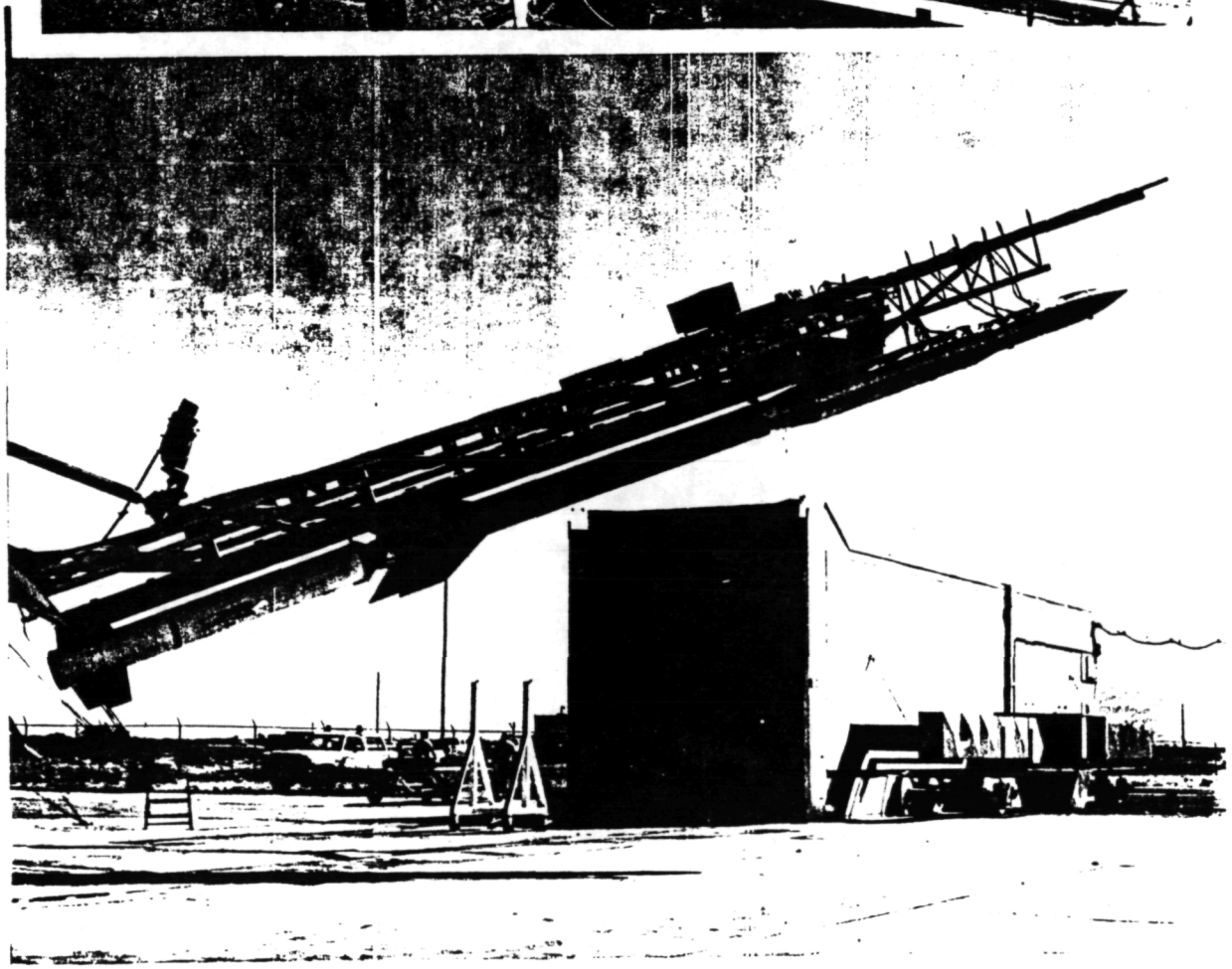
OBSERVATION SCENARIO

- LAUNCH WINDOW CONSTRAINTS ARE DETERMINED BY THE POSITION OF THE PLANETS AND MAY BE AS LIMITED AS ONE WEEK PER YEAR AND 15 MINUTES PER DAY.

- TWO GUIDE TARGETS MUST BE ACQUIRED BEFORE FINAL PAYLOAD MANEUVER TO TARGETS NEAR THE SUN.

- AFTER THE NEAR-SUN TARGET IS ACQUIRED TELESCOPE FINE-MODE CONTROL IS ACTIVATED ALLOWING THE TARGET IMAGE POSITION ON THE ENTRANCE SLIT OF THE SPECTROMETER.





UNIVERSITY OF COLORADO PAYLOAD

FIGURES DESCRIBING THE UNIVERSITY OF COLORADO PLANETARY ROCKET

FIGURE 1 Figure 1 shows a diagram of the science instrument which consists of a 40 cm diameter Cassegrain telescope and Ebert-Fastie spectrograph. A NASA provided star tracker is mounted in front of the secondary mirror and provides pointing information for the rocket attitude control system. During an observation a control system consisting of a gimbal mount for the secondary mirror and an optical sensor located near the telescope focal plane holds the image of a target stationary on the entrance slit of the spectrograph. The location of the image can be changed during flight by ground commands. The combination of ACS system, telescope image motion compensation, and ground commands allow the image of a target to be positioned to 1 arc second with less than 1 arc second of image jitter A sensitive TV camera which is used to monitor the position of the target image in the focal plane is not shown in this figure.

FIGURE 2. Figure 2 shows the science instrument combined with a sunshade which allows for pointing the telescope at targets within 17 degrees of the sun.

FIGURE 3. Figure 3 shows a typical viewing geometry for the instrument with the sunshade deployed.

FIGURE 4 Figure 4 shows the observing sequence for the planet Venus used during flight 27.110 UL which occurred in September 1988. The horizontal bars show the location and size of the spectrograph entrance slit as it appears on the telescope TV camera. During the flight the slit was moved by ground command 24 times to sweep form the equator to the south pole, off the limb, and then to approximately 50 degrees north latitude.

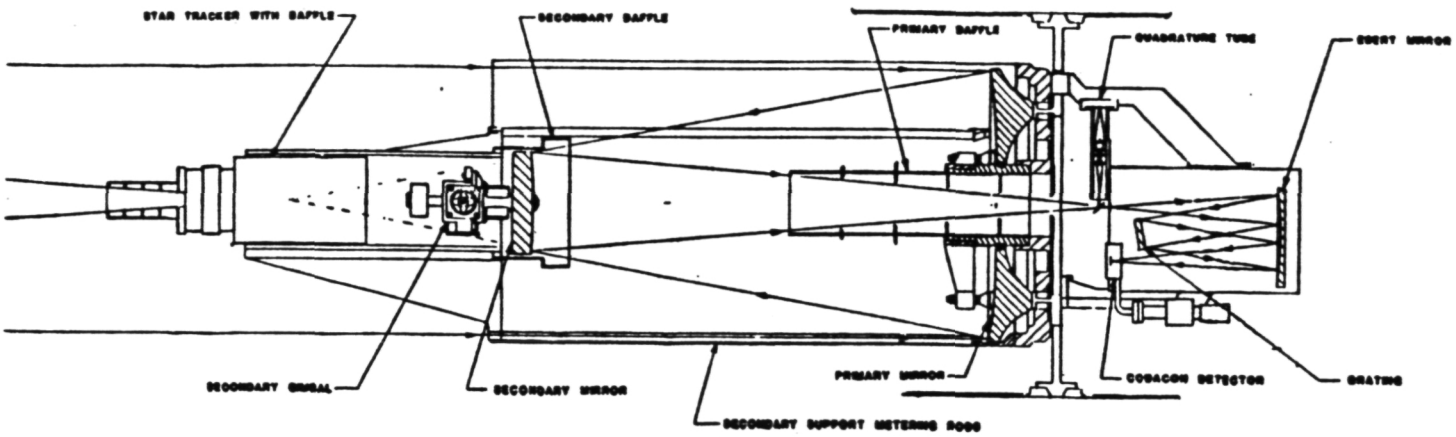


FIGURE 1. PLANETARY ULTRAVIOLET TELESCOPE-SPECTROGRAPH

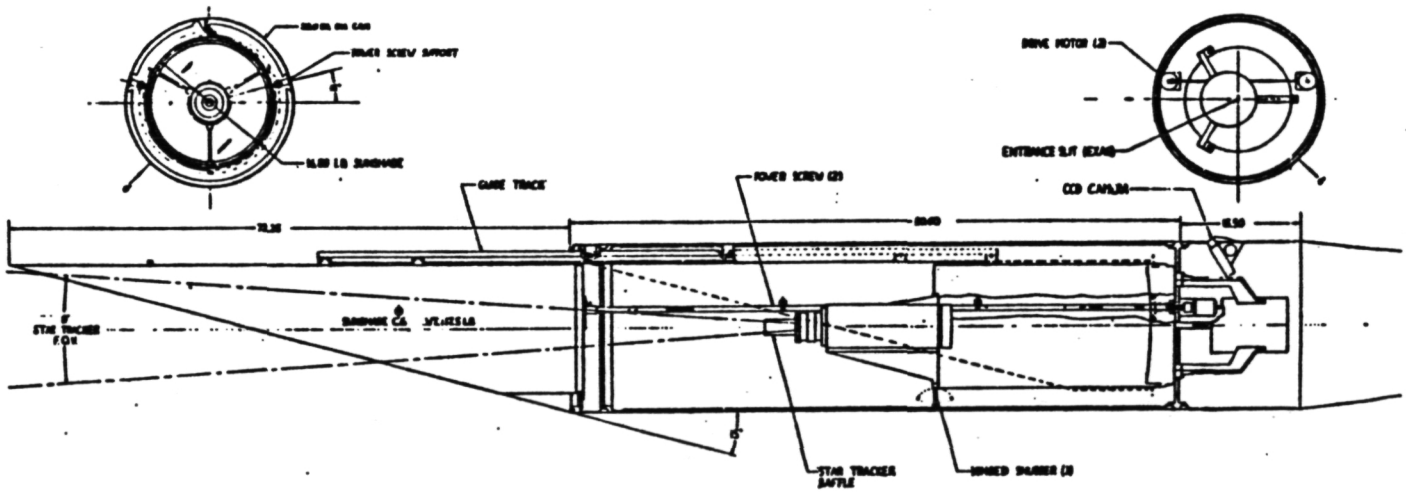


FIGURE 2. COLORADO PLANETARY ULTRAVIOLET TELESCOPE-SPECTROGRAPH EQUIPPED WITH A 17° SUNSHADE

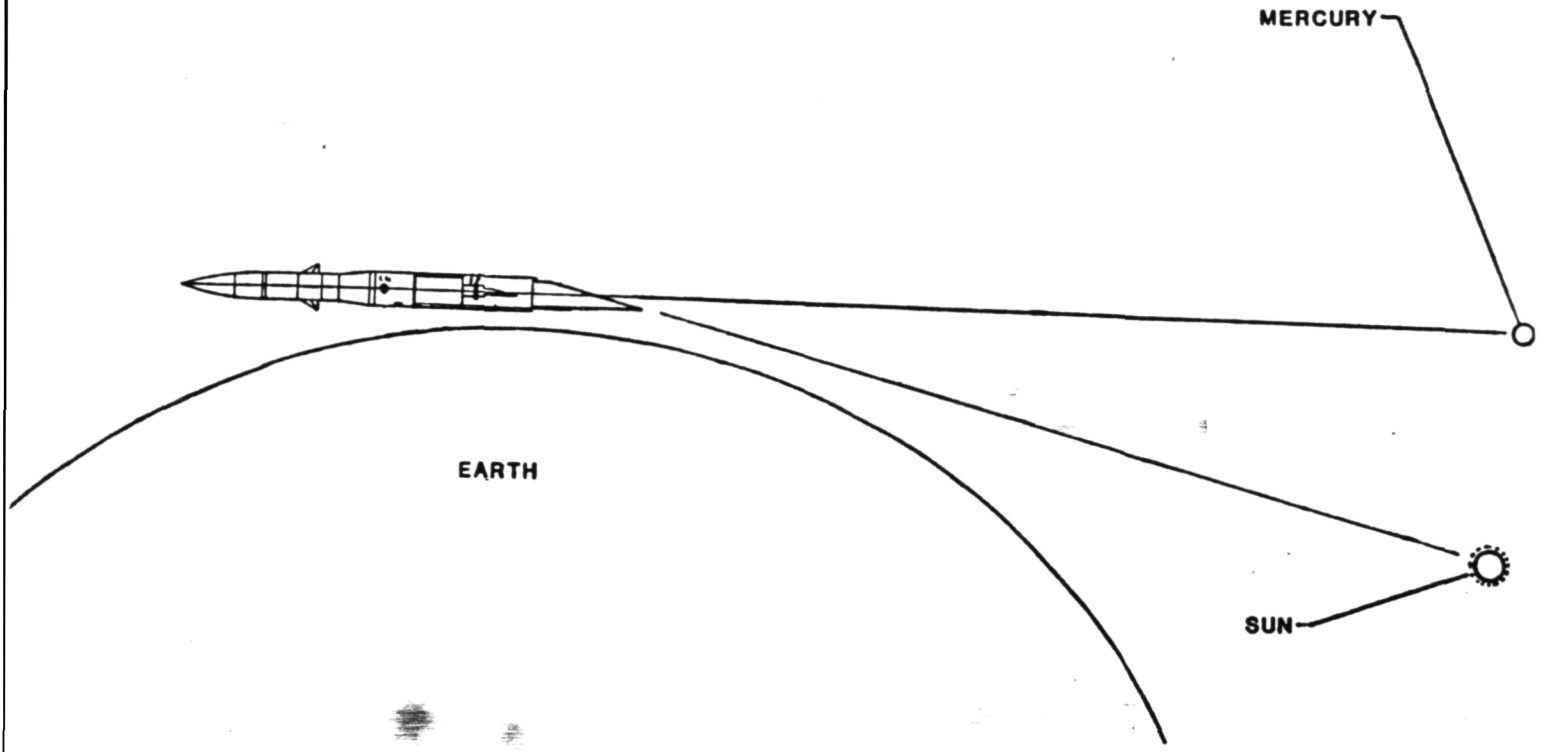


FIGURE 3.

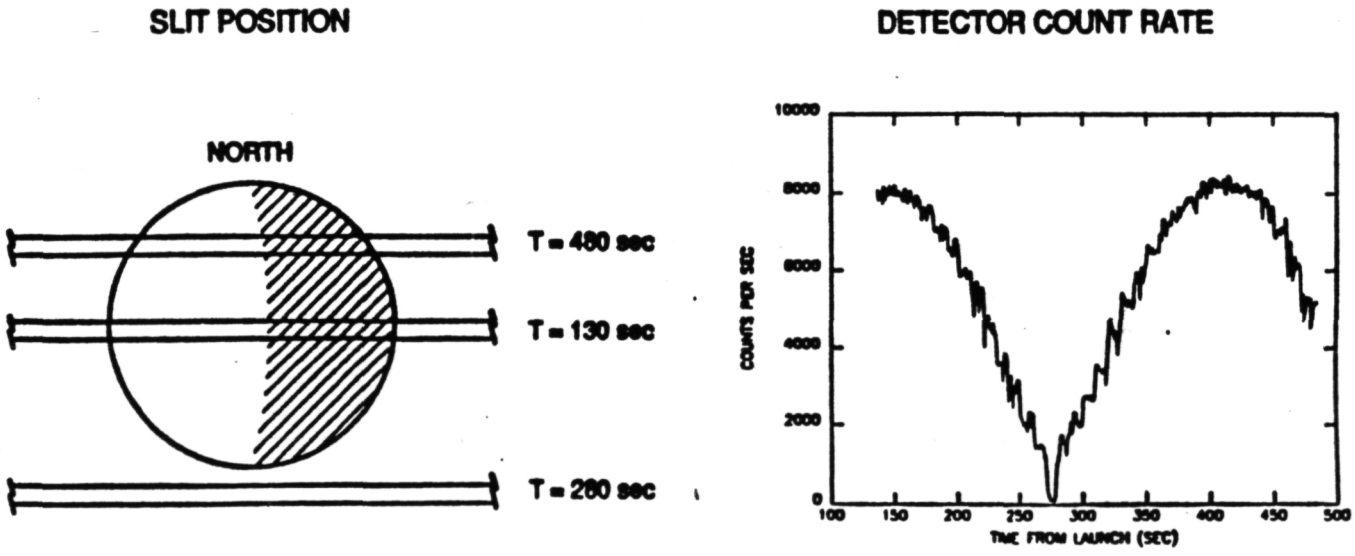


FIGURE 4. VIEWING GEOMETRY FOR ROCKET 27.110

2. SUPPORTING SERVICES

- Parts/component advice, certifications, reliability, supply
- Modelling --- temperatures, **g**-forces, vibrations, etc.
- Testing --- Q/A, flight readiness
- Trajectories --- simulations, targeting

- LOGISTICS

---- "Traditional" sites

---- Specialized campaigns

---- Equipment shipping to remote sites

---- Groundbased diagnostic sites --- telecommunications for real-time decisions on launch

--- Science team travel to specialized sites
-- e.g., use of MAC

EXAMPLES OF LOGISTICAL CONCERNS

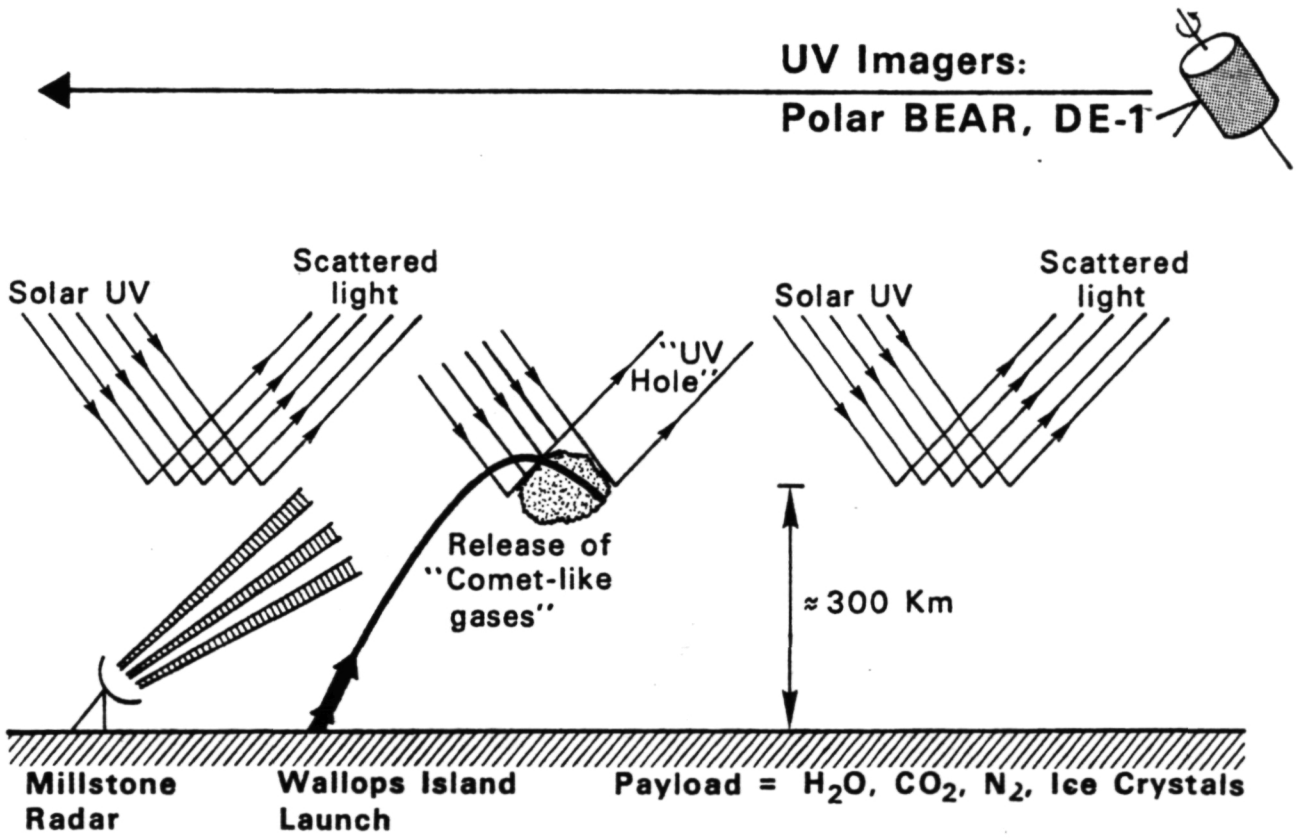
- Traditional Site --- ERIC Experiments at Wallops Island

- Specialized Campaigns --- COPE/Greenland, 1987

  --- CRRES/Kwajalein, 1990

Environmental Reactions Induced by Comets

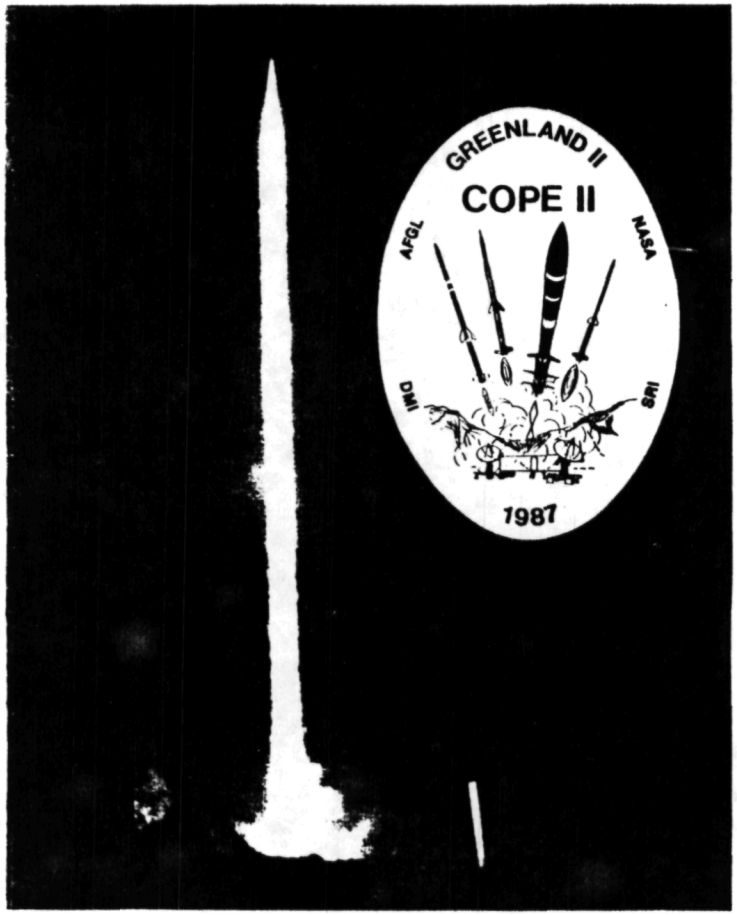
Project ERIC - - Experiment Design



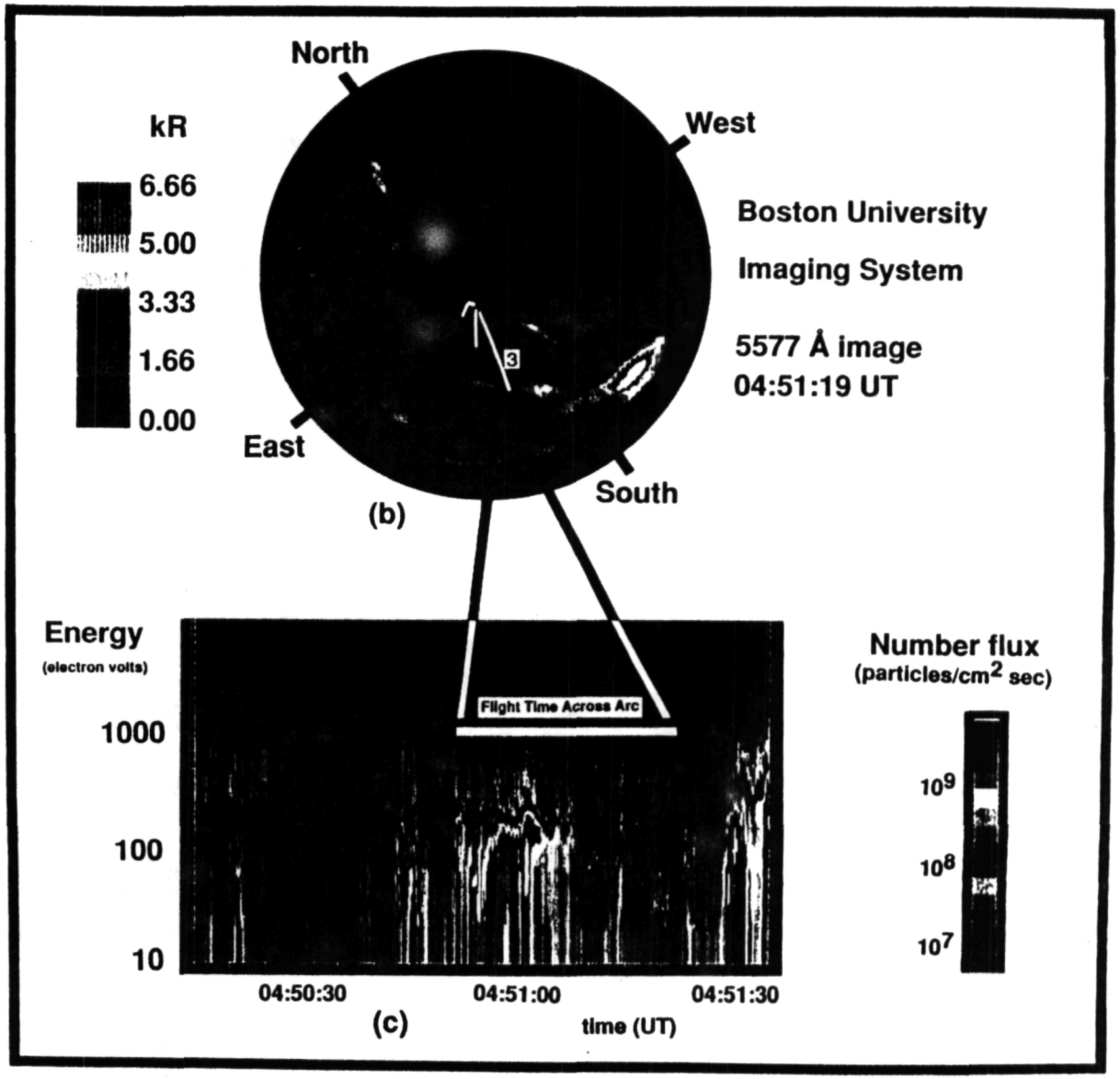
Sondre Stromfjord
March 31 1987

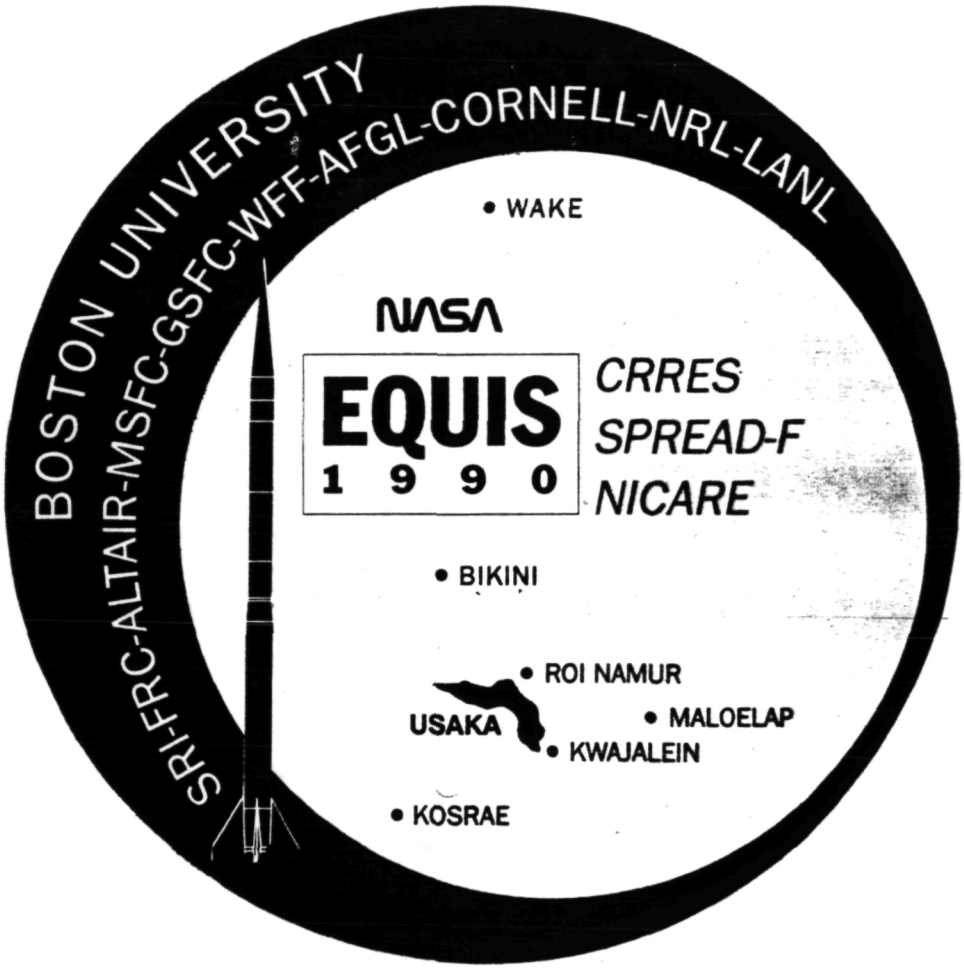
Cooperative Observations of Polar Electrodynamics

CORNELL UNIVERSITY PAYLOADS



(a)




BOSTON UNIVERSITY
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• ROI NAMUR
USAKA
• MALOELAP
• KWAJALEIN
• KOSRAE

3. SPECIAL REQUIREMENTS

- FLEXIBILITY
- MORE FLEXIBILITY
- Training of students (science & engineering)
- Access to space for new investigators
- Instrument development
- Launch windows that are target and site dependent
  (e.g., eclipse)
  or seasonally dependent
  (e.g., equatorial ionospheric instabilities)
- Launch criteria that are event dependent
  (e.g. auroral displays)
- Coordination with satellite passes
- Quick response to unanticipated events
  (e.g., supernova)
  or targets-of-opportunity
  (Ulysses-Jupiter encounter)

NASA SPACE SCIENCE

SUBORBITAL ROCKET PROGRAM WORKSHOP

(PROGRAM IMPLEMENTATION/OPERATIONS)

NOVEMBER 12-13, 1991

NASA SOUNDING ROCKETS

SPECIAL FEATURES

- HIGH RELIABILITY
- SHORT MISSION LEAD TIME
- LOW COST
- MOBILE
- PAYLOAD RECOVERY AND RE-USE
- APPLICABILITY TO GRADUATE SCHOOL RESEARCH PROGRAMS

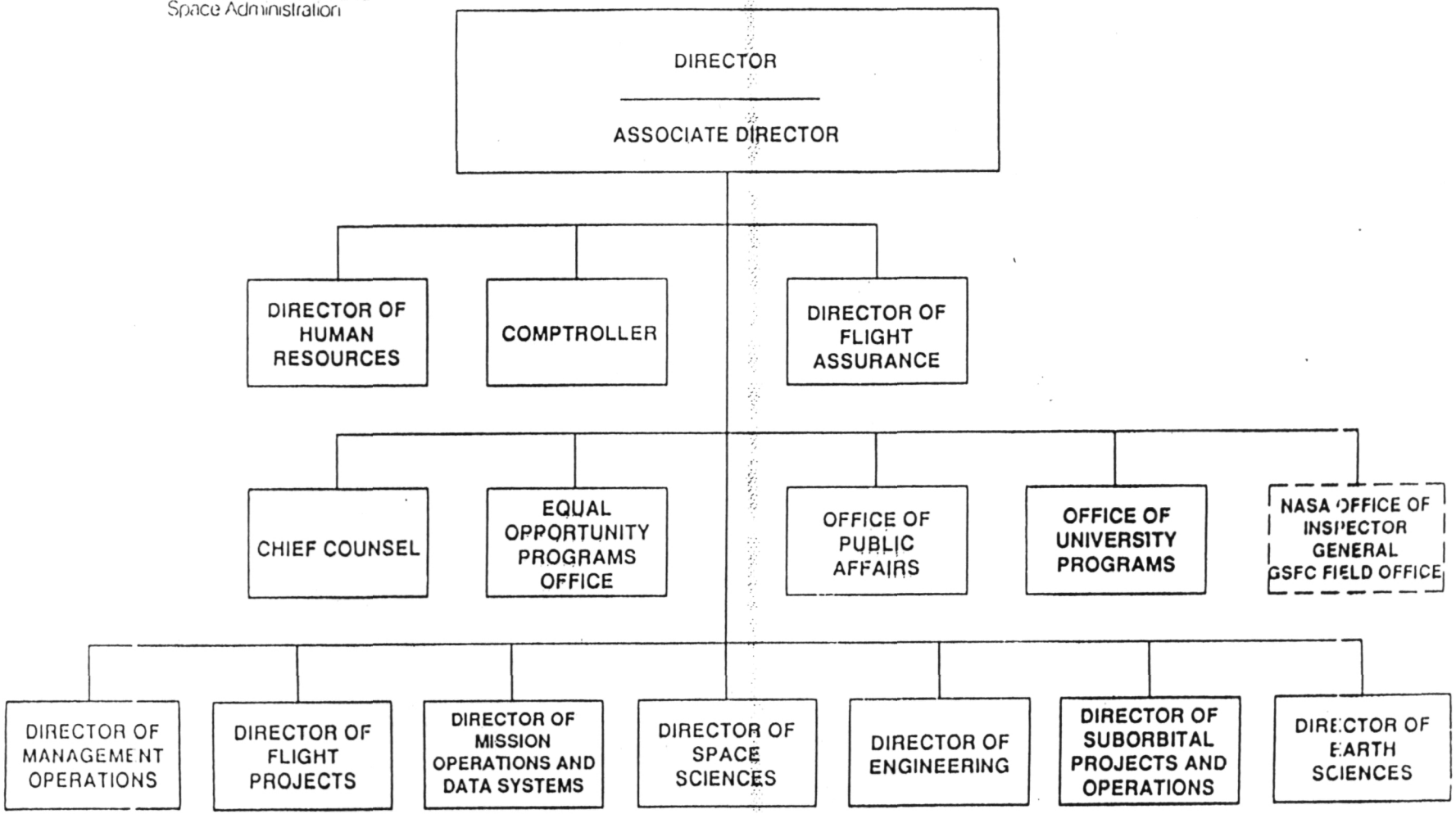
NASA SOUNDING ROCKET PROGRAM

OVERVIEW

- **~30 SOUNDING ROCKETS PER YEAR**
  - PAYLOADS RANGE - 5 TO 1150 KILOGRAMS
  - PEAK ALTITUDES RANGE - 70 TO 1500 KM
- **SERVES SCIENTIFIC COMMUNITY**
  - UNIVERSITIES
  - NASA
  - INTERNATIONAL
  - OTHER GROUPS
- **PROGRAM SUPPORT**
  - PLASMA PHYSICS
  - UPPER ATMOSPHERE
  - GALACTIC ASTRONOMY
  - SOLAR PHYSICS
  - HIGH ENERGY ASTROPHYSICS
  - PLANETARY ATMOSPHERES
- **OVER 2500 TOTAL MISSIONS SINCE 1959**
  - AT OVER 86% MISSION SUCCESS
- **398 MISSIONS IN PAST ELEVEN YEARS**
  - AT 88% MISSION SUCCESS
  - AT 98% VEHICLE SUCCESS

NASA
National Aeronautics and Space Administration

GODDARD SPACE FLIGHT CENTER



APPROVED James R. Thompson

DATE 8/29/90

NASA SOUNDING ROCKET PROGRAM

GSFC/CODE 800 PRIMARY SUPPORT

- MANAGEMENT
- DEVELOPMENT AND PROCUREMENT OF PAYLOADS/SPECIAL SYSTEMS
- DEVELOPMENT AND PROCUREMENT OF LAUNCH VEHICLES
- PAYLOAD TESTING AND EVALUATION
- ANALYTICAL STUDIES
- LAUNCH RANGE OPERATIONS/INTERFACES
- TRACKING AND DATA ACQUISITION AND DATA PROCESSING

NASA SOUNDING ROCKET PROGRAM

LAUNCHES BY DISCIPLINE

FISCAL YEAR	80	81	82	83	84	85	86	87	88	89	90	91
GALACTIC ASTRONOMY	4	5	3	5	4	4	4	1	3	2	6	2
HIGH ENERGY ASTROPHYSICS	5	2	4	3	1	1	2	0	4	1	1	2
SOLAR PHYSICS	9	2	3	5	1	1	1	4	5	4	0	6
PLASMA PHYSICS	17	25	26	29	24	21	14	18	16	10	17	10
UPPER ATMOSPHERE	11	7	4	6	6	9	9	5	3	4	1	2
PLANETARY ATMOSPHERES	3	4	5	3	3	1	3	1	1	4	3	2
OTHER	2	3	0	2	1	0	0	0	1	0	2	1
TOTAL	51	48	45	53	40	37	33	29	33	25	30	25

11-06-91 LAUDISTB

NASA Sounding Rocket Launch Locations

*Andoya, Norway - Fixed Range (Full Facilities)
Antigua, U.K. - Mobile Range Site
Ascension Island, U.K. - Mobile Range Site
Barking Sands, HI - Fixed Range (Full Facilities
Barter Island, AK - Mobile Range Site
Cape Parry, Canada - Mobile Range Site
Camp Tortuguera, Puerto Rico - Mobile Range Site
Chikuni, Canada - Mobile Range Site
Coronie, Suriname - Mobile Range Site
Eglin AFB, FL - Fixed Range (Full Facilities)
El Arenosillo, Spain - Fixed Range
Fort Churchill, Canada - Fixed Range (Decommissioned)
Fort Greely, AK - Mobile Range Site
Fort Sherman, Panama - Mobile Range Site
Fox Main, Canada - Mobile Range Site
Karachi, Pakistan - Fixed Range
Karikari, New Zealand - Mobile Range Site
Kerguelen Island, France - Mobile Range Site
Keweenaw, MI - Mobile Range Site
*Kiruna (Esrange), Sweden - Fixed Range (Full Facilities)
Kourou, French Guiana - Fixed Range (Full Facilities)
*Kwajalein, Marshall Is. - Fixed Range (Full Facilities)
Natal, Brazil - Fixed Range (Full Facilities)
Point Barrow, AK - Fixed Range (Decommissioned)
Point Mugu, CA - Fixed Range (Full Facilities)
*Poker Flat Research Range, AK - Fixed Range (Full Fac.)
Primrose Lake, Canada - Mobile Range Site
Punta Lobos, Peru - Mobile Range Site
Red Lake, Canada - Mobile Range Site
Resolute Bay, Canada - Mobile Range Site
San Marco, Kenya - Fixed Range
Sardinia, Italy - Mobile Range Site
Siple Station, Antarctica - Mobile Range Site
*Sondre Stromfjord, Greenland - Mobile Range Site
Thumba, India - Fixed Range
U.S.N.S. Croatan - Shipboard Range (Decommissioned)
U.S.N.S. Range Recoverer - Shipboard (Decommissioned)
*Wallops Island, VA - Fixed Range (Full Facilities)
Western Test Range, CA - Fixed Range (Full Facilities)
*White Sands Missile Range, NM - Fixed Range (Full Fac.)
*Woomera, Australia - Fixed Range (Partial Facilities)

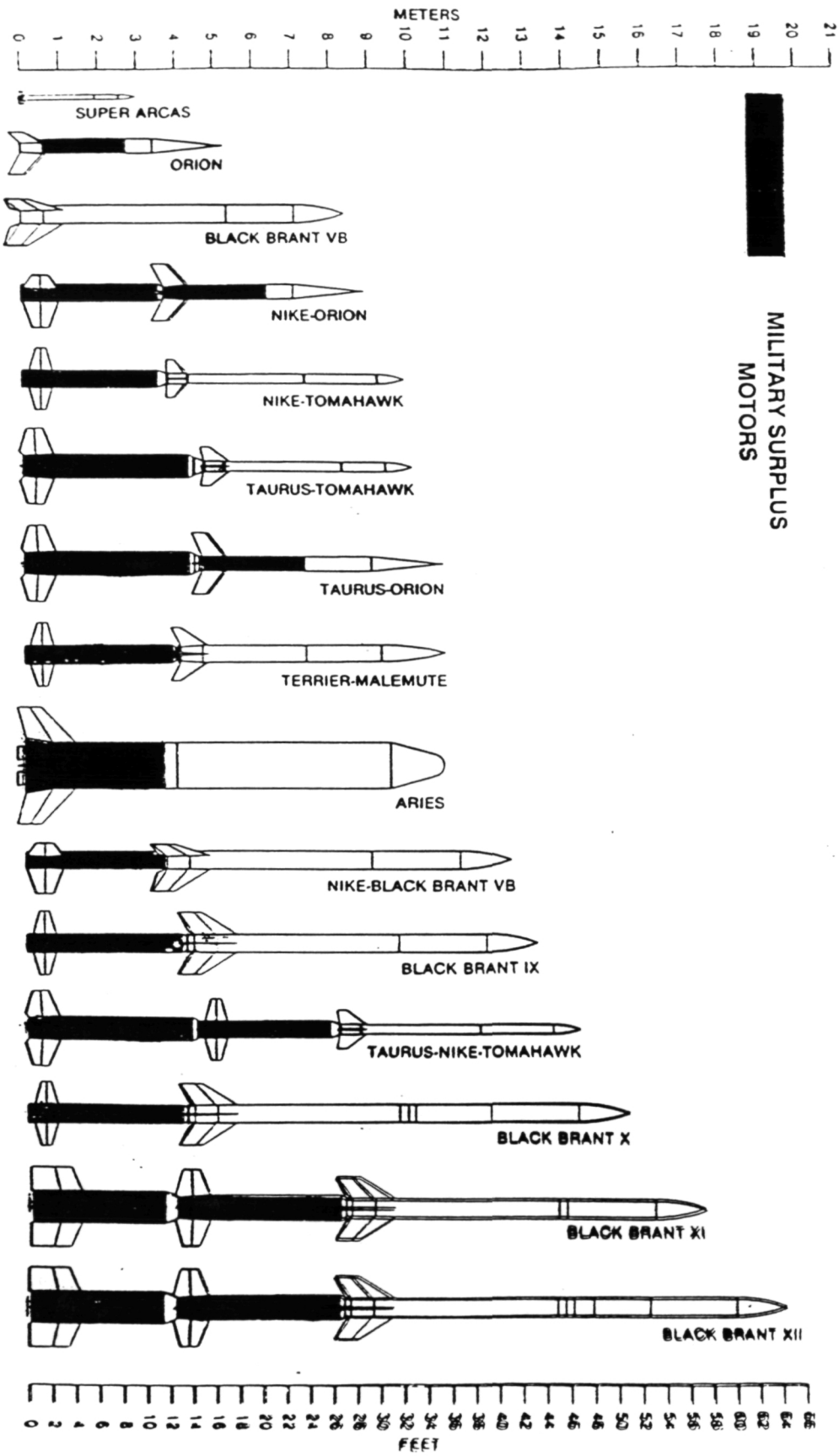
*Currently used sites

NASA SOUNDING ROCKET PROGRAM
LAUNCHES BY LOCATION

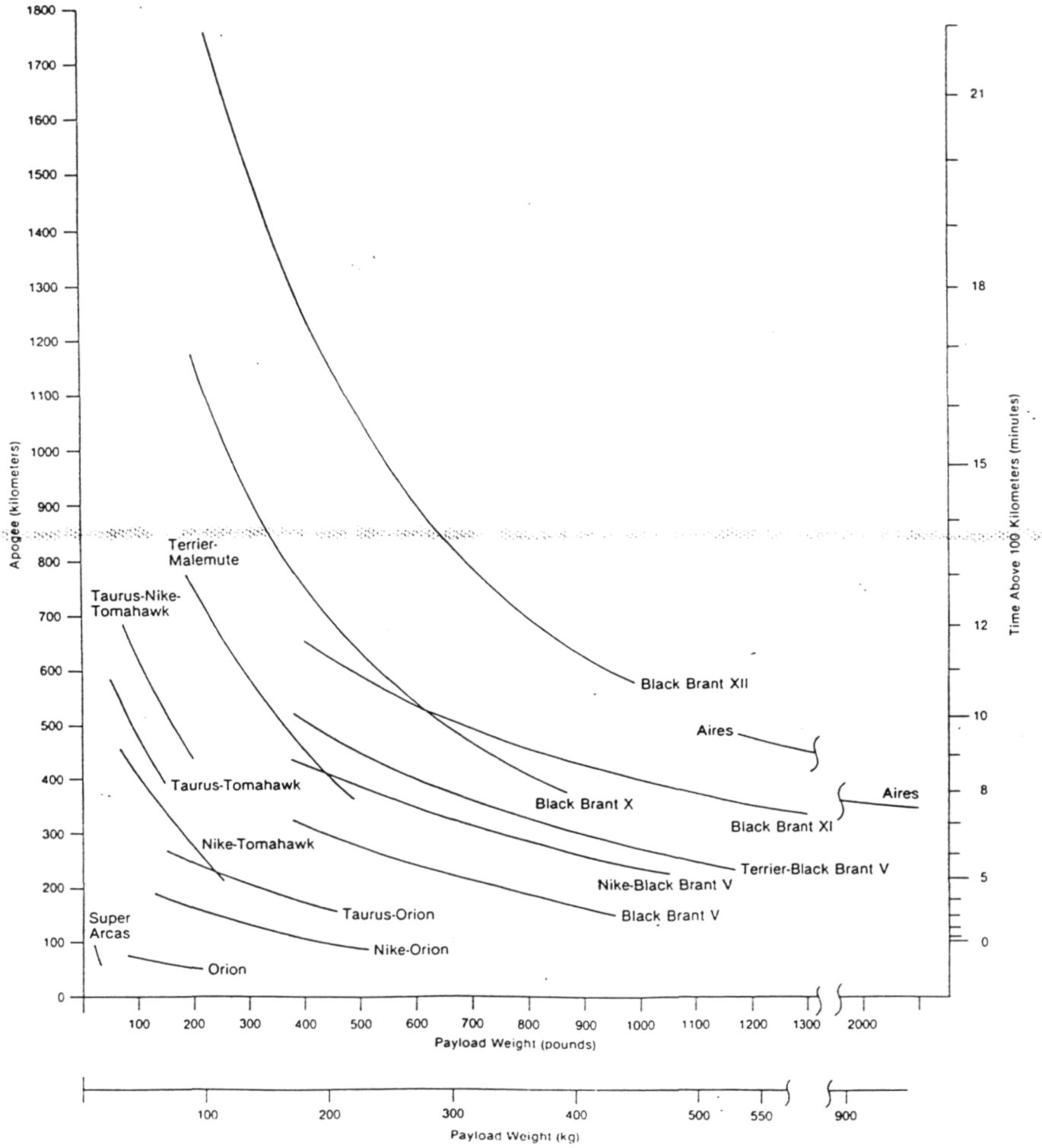
	80	81	82	83	84	85	86	87	88	89	90	91
ANTARCTICA - SIPLE STATION		7										
ALASKA - FORT YUKON					1							
POKER FLAT	5	2	14	5	7	8	8	2	3	2	7	3
AUSTRALIA - WOOMERA									6			
CANADA - CAPE PARRY			4									
CHURCHILL RSCH. RNG.	1	3	4	2	3	3				4		
GREENLAND - SONDRE STROMFJ.						7		8				
KWAJALEIN											7	
KENYA - SAN MARCO	7											
NORWAY - ANDOYA		6	1		1		2	4	8	3		1
PERU - PUNTA LOBOS				18								
SWEDEN - KIRUNA		4					3		1	2		7
WALLOPS ISLAND - VIRGINIA	14	12	4	7	17	6	6	7	5	2	4	1
WHITE SANDS - NEW MEXICO	24	14	18	21	11	13	14	8	10	12	12	13
TOTAL	51	48	45	53	40	37	33	29	33	25	30	25

11-05-91 LAULOC

NASA Sounding Rockets

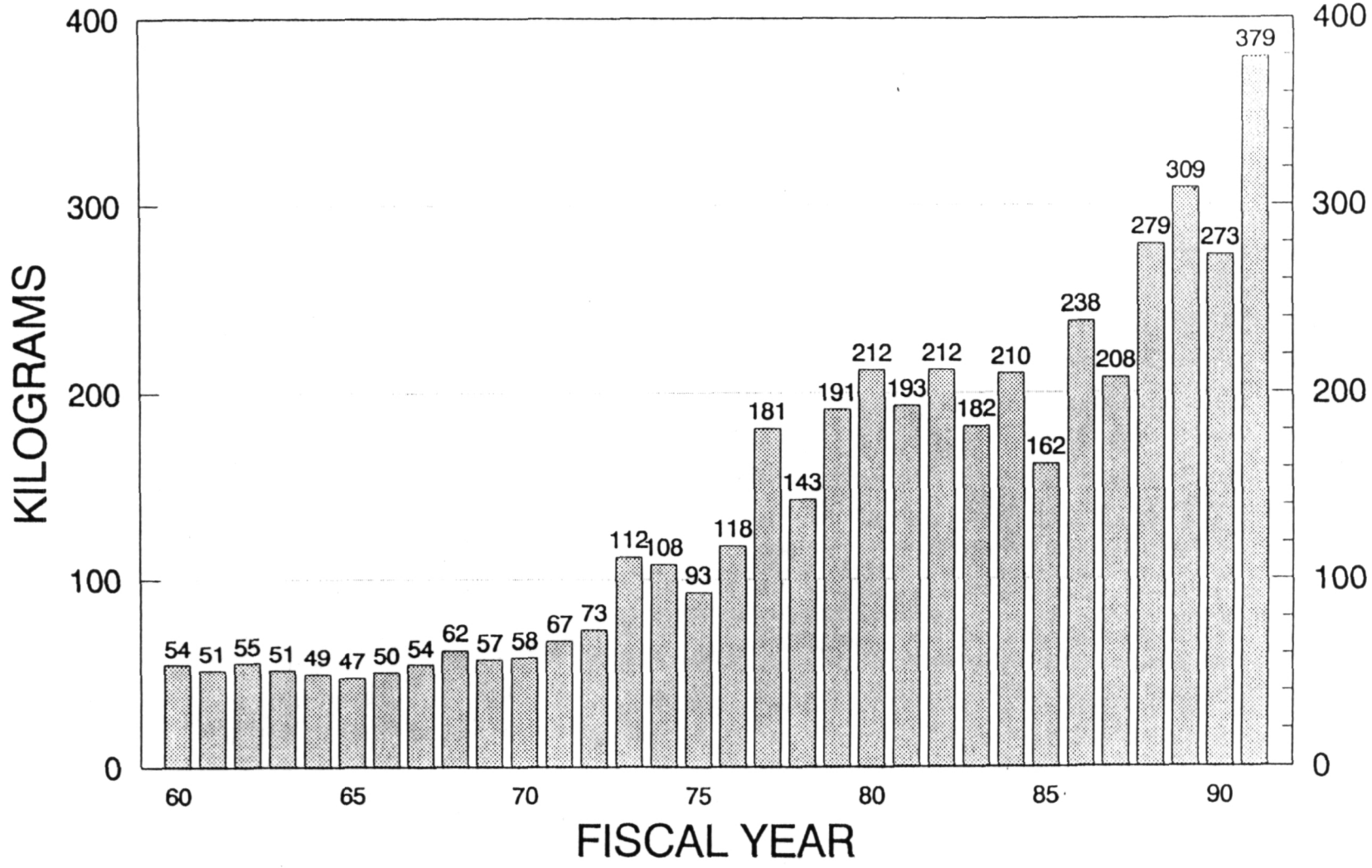


NASA Sounding Rocket Performance



NASA SOUNDING ROCKETS

GROWTH IN AVERAGE WEIGHT OF PAYLOADS



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NASA SOUNDING ROCKET PROGRAM
LAUNCHES BY VEHICLE

	79	80	81	82	83	84	85	86	87	88	89	90	91
24 ARIES	2	1	1	1		1		1					1
04 AEROBEE 150		2		1	2		1						
13 AEROBEE 170	2												
17 AEROBEE 350				1	1	1							
23 ASTROBEE D	6	4											
25 ASTROBEE F	12	9	3	1									
15 SUPER ARCAS	5	4	6	3	9	6	2	5	4				3
21 BLACK BRANT V	4	1	2	1	4	3	3	2		1	4		3
27 NIKE-BLACK BRANT	6	11	8	9	9	6	4	4	5	3	2	2	1
36 BLACK BRANT IX					2			5	6	15	9	12	11
35 BLACK BRANT X				4	1	3	2	5	1	2	5	2	
39 BLACK BRANT XI												1	
40 BLACK BRANT XII												1	1
30 ORION		3	8	1	2	2	6	1	2	3		1	
31 NIKE-ORION	2	7	3	10	8	9	9	5	1	7	2	1	4
33 TAURUS-ORION	2	4	11	4	10	4	5	1	3		2	2	
38 TAURUS-NIKE-TMHWK						2		3	3	1		4	
34 TAURUS-TOMAHAWK	3	3	2	2	2		2		1				
18 NIKE-TOMAHAWK	9		3	4			1		1				
29 TERRIER-MALEMUTE	3	1		3	2	2	2	1	2		1	2	
12 SPECIAL		1	1		1	1				1		2	1
TOTAL	56	51	48	45	53	40	37	33	29	33	25	30	25

11-05-91 LAUVEH

LAUNCH VEHICLE SUPPORT FOR NASA SOUNDING ROCKET PROGRAM

- PURCHASE COMMERCIAL SOLID PROPELLANT ROCKET MOTORS/HARDWARE
  - BLACK BRANT V (BRISTOL)
  - NIHKA (BRISTOL)
  - TOMAHAWK (THIOKOL)
  - MALEMUTE (THIOKOL)
  - SUPER ARCAS (ATLANTIC RESEARCH)
- EXTENSIVE USE OF SURPLUS TACTICAL ROCKET MOTORS/HARDWARE
  - HAWK, IMPROVED HAWK
  - NIKE
  - IMPROVED HONEST JOHN
  - TALOS
- CONTRACT PURCHASE OF OTHER VEHICLE HARDWARE
- UTILIZE S-19 BOOST-GUIDANCE SYSTEM AT WHITE SANDS MISSILE RANGE
- USE SUPPORT CONTRACTORS (*ON AND OFF-SITE*)
  - MISSION ANALYSES
  - SYSTEMS ENGINEERING
  - PROTOTYPE FABRICATION
  - VEHICLE ASSEMBLY/LAUNCH OPERATIONS
- AVERAGE ANNUAL EXPENDITURE APPROXIMATELY $8M

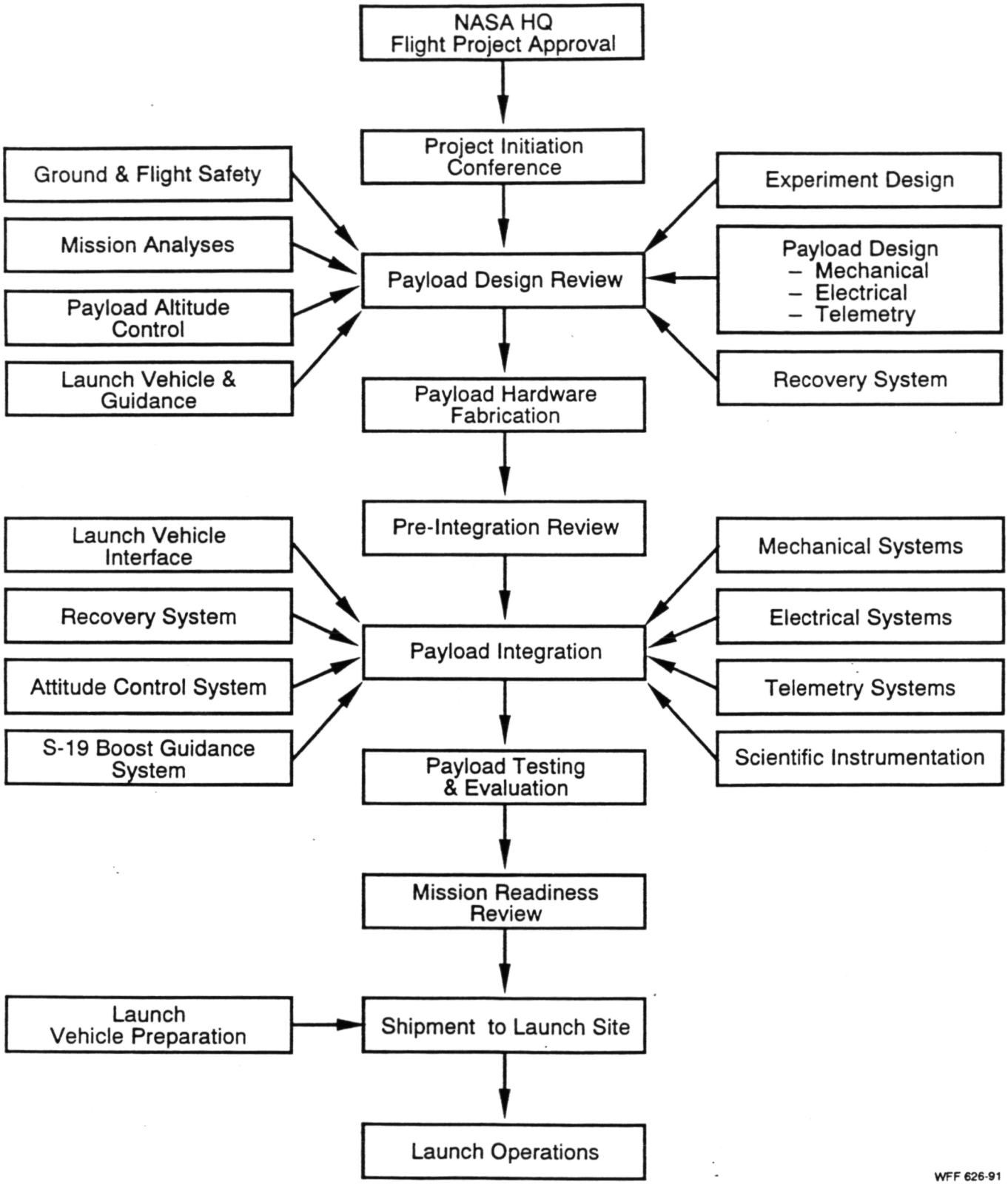
SPECIAL CHARACTERISTICS/REQUIREMENTS OF SOUNDING ROCKET LAUNCH VEHICLES

- **PROGRAMMATIC**
  - **R&D NATURE OF PROGRAM**
  - **WIDE VARIATION IN PERFORMANCE REQUIREMENTS**
  - **QUICK RESPONSE PROJECTS**
  - **SHORT PROJECT LIFETIMES**

- **PAYLOAD INTERFACES**
  - **PAYLOAD VARIABILITY**
  - **PAYLOAD CHANGES**
  - **PAYLOAD PART OF VEHICLE STRUCTURE**
  - **VEHICLE SYSTEMS INTEGRATED INTO PAYLOAD**

- **OPERATIONAL**
  - **UNGUIDED LAUNCH VEHICLES (LARGE DISPERSION)**
  - **LAUNCH FROM TEMPORARY/REMOTE SITES**
  - **LAUNCH FROM FOREIGN RANGES**
  - **FIELD REFURBISH/REFLY**
  - **SPECIAL FLIGHT SAFETY CONCERNS (WIND COMPENSATION)**
  - **SALVO LAUNCH SEQUENCES**

Typical Sounding Rocket Project Flow Diagram



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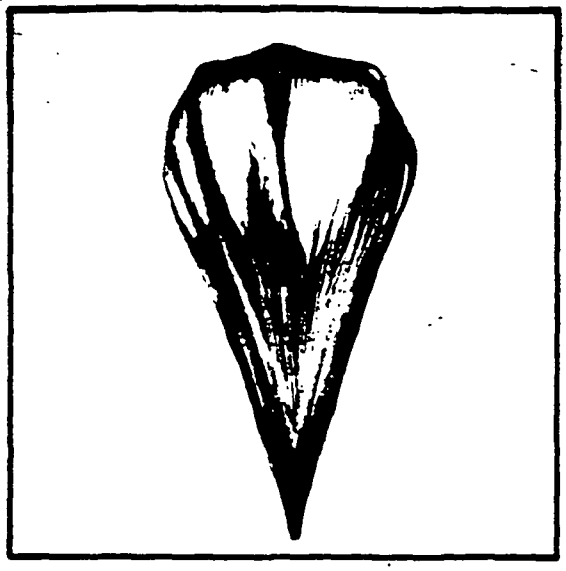
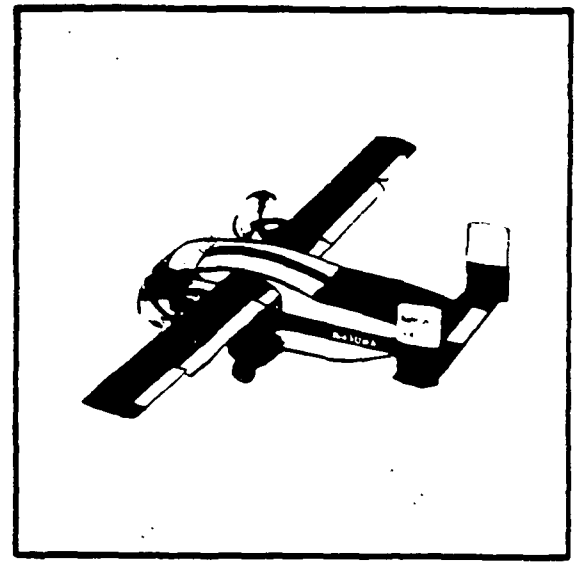
NASA SOUNDING ROCKET PROGRAM

VEHICLE SUCCESS

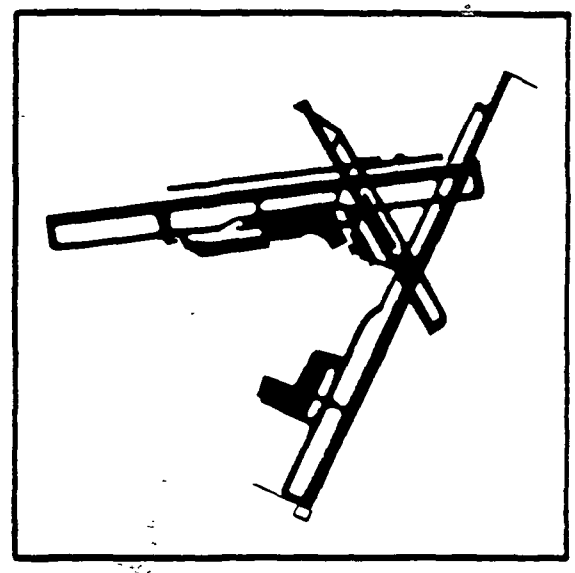
FY	LAUNCHES	LAUNCH SYSTEM FAILURES	SUCCESS RATE %
81	48		100
82	45	1	98
83	53	2	96
84	40		100
85	37	1	97
86	33	2	94
87	29	1	97
88	33		100
89	25	2	92
90	30		100
91	25	1	96
OVERALL	398	10	98

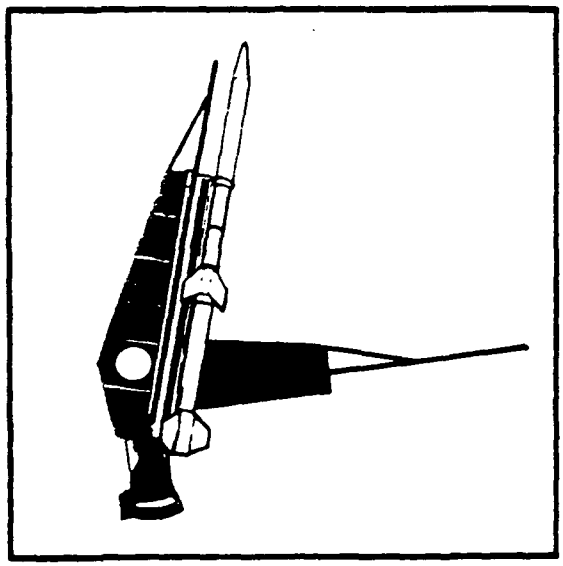


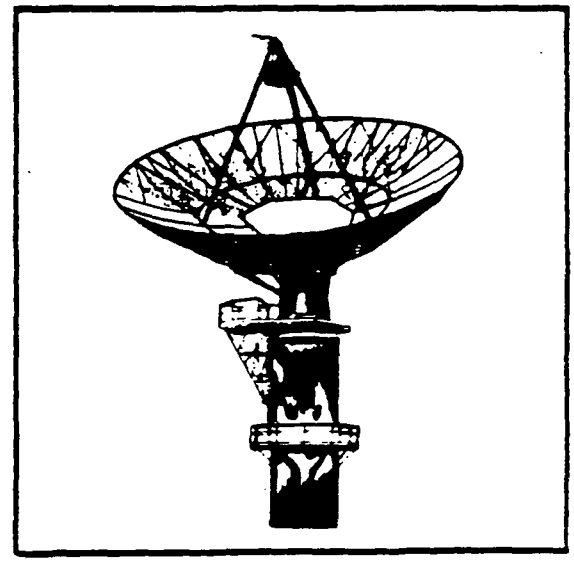


Wallops

a guide to the facility







NASA AGREEMENT/SUBAGREEMENT IMPLEMENTATION PROCESS